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Team-Based Assessment of Socio-Technical Logistics (TASL)

Patrick J. Vincent

Northrop Grumman Information Technology
2555 University Blvd.
Fairborn OH 45324

Jill Ritter

Air Force Research Laboratory
Logistics Readiness Branch

Laura Militello

University of Dayton Research Institute
300 College Park Drive
Dayton OH 45469

Nancy Cooke

The Cognitive Engineering Research Institute
5810 South Sossaman Road, Suite 106
Mesa AZ 85212

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Wright-Patterson AFB OH 45433-7604

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//SIGNED//
JILL A. RITTER
Program Manager
Logistics Readiness Branch

//SIGNED//
DANIEL R. WALKER, Colonel, USAF
Chief, Warfighter Readiness Research Division
Human Effectiveness Directorate
Air Force Research Laboratory

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[1]Patrick J. Vincent, [2]Jill Ritter, [3]Laura Militello,
[4]Nancy Cooke

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
[1]Northrop Grumman Information Technology
2555 University Blvd.
Fairborn OH 45324

[3]University of Dayton Research Institute
300 College Park Drive
Dayton OH 45469

[4]The Cognitive Engineering Research Institute
5810 South Sossaman Road, Suite 106
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14. ABSTRACT

The primary objective of the Team-Based Assessment of Socio-Technical Logistics (TASL) research effort was to improve warfighter team performance in distributed, operational environments involving collaborative logistics activities such as crisis action planning, dynamic re-planning, and command and control. In support of this objective, research goals were focused on improving human collaboration in crisis action planning and/or command and control environments, and expanding our knowledge and understanding of the impact of collaborative systems on human (team) behavior and performance.

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Table of Contents

Table of Figures

1.0 Introduction

The Team-Based Assessment of Socio-Technical Logistics (TASL) research program was sponsored by the Air Force Research Laboratory's Logistics Readiness Branch (AFRL/RHAL) under the Technology for Agile Combat Support (TACS) contract (FA 8650-D-6546, Delivery Order #3). The TASL research was accomplished during the period of 10 June 2005 to 9 April 2008. The purpose of the TASL program was to research and develop methodologies, frameworks, and metrics that in turn, could be applied to support the evaluation of Socio-Technical Systems (STS) and Computer Supported Cooperative Work (CSCW) technologies. The overarching goals of the TASL program included the following:

- Analyzing collaborative systems and technologies from a socio-technical perspective for the purpose of:
    - Developing an in-house, socio-technical research capability to assess and inform the design, development, and implementation of collaborative systems in military planning and command and control environments (particularly logistics).
    - Performing field research in selected environments to inform the design and execution of controlled, in-house experimentation activities to examine various aspects of collaboration (e.g., communication modes, team roles, etc.).
- Acquiring a better understanding of the social context of work in real-world STS environments.

The primary objective of the TASL research effort was to improve warfighter team performance in distributed, operational environments involving collaborative logistics activities such as crisis action planning, dynamic re-planning, and command and control. In support of this objective, research goals were focused on improving human collaboration in crisis action planning and/or command and control environments, and expanding our knowledge and understanding of the impact of collaborative systems on human (team) behavior and performance.

1.1 Background

As the need for communication and collaboration among distributed teams has increased, the world has seen an explosion in software and hardware technologies (e.g., web conferencing, shared whiteboards, etc.) intended to support a range of complex work activities related to decision making, planning, problem solving, developing courses of action, etc. Systems engineering design methodologies used to develop traditional collaborative systems have not kept pace with the increasingly complex collaboration required in today's military. Transaction based processing systems that were primarily designed to support single users interfacing with a computer – not the collaboration among multiple users and systems – are no longer sufficient. Potential users of these technologies and systems can find the technical options overwhelming and difficult to compare. In fact, few methodologies, frameworks, or metrics exist to evaluate how individual and team performance is impacted by the introduction of collaborative technologies and systems in organizations. As a result, technologies are often purchased and placed within an existing organizational structure with little understanding of how the technology changes the way work gets done and how it will support or hinder a team (and organization) in accomplishing its goals. The emergence of ubiquitous computing as the next wave of organizational computing offers new possibilities and opportunities for organizations to improve their productivity and effectiveness. However, we need a better understanding of how these technologies affect organizations and the social context of the work for which collaborative systems are intended to support. The "social" context includes organizational culture, team and group dynamics, individual personalities, etc. (Rogers and Bellotti, 1997).

Very detailed computing architectures have been published that emphasize the information technology (IT) aspects (i.e., system interoperability, networking, information assurance, etc.) associated with collaboration technologies. In fact, because of the growing interest in leveraging collaboration technologies to support distributed operations, the Department of Defense (DoD) has given considerable attention to the testing of collaboration technologies through programs such as the DoD Defense Collaboration Tool Suite (DCTS) managed by the Defense Information Systems Agency

(DISA). However, the emphasis of the testing associated with these technologies or applications is primarily from an IT perspective (i.e., security and interoperability) against well-defined requirements or standards. What is lacking is a full consideration of the *human* aspects of system operation, and in particular how collaborative technologies or CSCW applications improve or impede human performance in distributed environments involving collaboration between warfighters. The powerful networked computing environments supporting the implementation of collaborative technologies and applications will not reach their full potential without explicit consideration of the human-centric element. The TASL program focused on addressing this gap by researching and making progress toward developing a framework for assessing collaborative technologies and teams from a human and organizational perspective, recognizing that simply testing collaborative technologies and systems (hardware/software) from a reliability and network connectivity standpoint does not guarantee successful implementation.

1.2 Terminology

1.2.1 Socio-Technical System (STS)

A Socio-Technical System (STS) theory views work organizations as comprised of two interdependent subsystems – a technical subsystem and a social subsystem, as depicted in Figure 1.

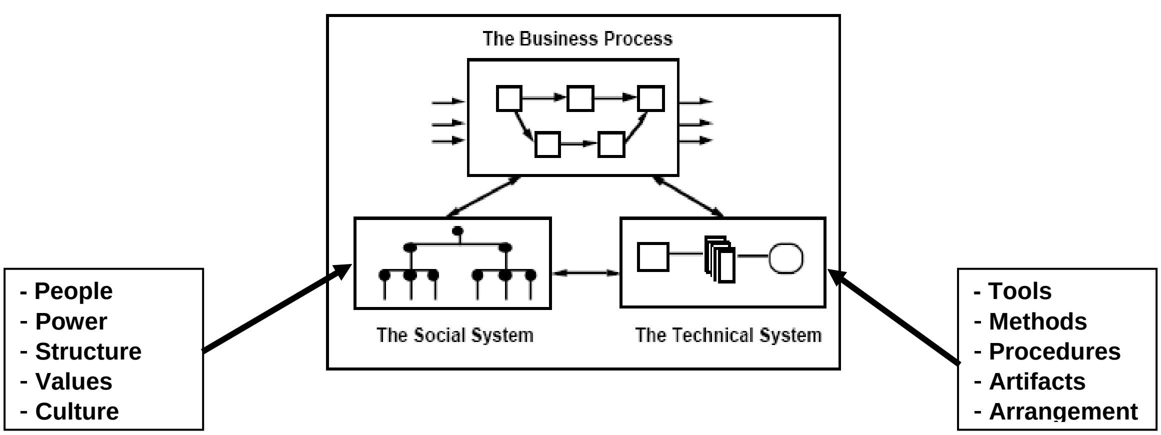

Figure 1. Socio-Technical System Perspective

The technical subsystem includes the operating policies and procedures, business methods, and task procedures guiding the accomplishment of work, as well as the information technology and software applications supporting the same. The social subsystem encompasses the individuals working in the organization, including the knowledge, attitudes, values and needs they bring to the work environment, as well as the organizational culture, power hierarchy, and reward systems within the organization. These subsystems have a direct impact on business processes and are therefore a key area of interest in STS design practices that attempt to take into account the network of users, developers, information technologies, and the environments in which a system will be used and supported. The STS design process includes the design of the human-computer interface and patterns of human-computer interaction. It stands in opposition to traditional system or software engineering design methods that focus attention exclusively or primarily on the *activities* of system engineers who design the computational functions and features of a new system, and who use computer-aided design tools and techniques such as the Unified Modeling Language (UML) to capture, formalize, and portray the results of such a design process. In contrast, STS design is concerned with advocacy of the direct participation of end-users in the information system design process (Scacchi, 2004). Some examples of socio-technical systems include emergency response systems, logistics planning systems, remote medicine, and unmanned aerial vehicle ground control systems.

1.2.2 Computer Supported Cooperative Work (CSCW)

Computer Supported Cooperative Work (CSCW) refers to the theoretical foundations and methodologies for teamwork and corresponding computer support. It is concerned with how collaborative activities and their coordination can be best supported by means of computer systems (Carstensen and Schmidt, 2003). CSCW attempts to combine the understanding of the way people work in groups with the enabling technologies of computer networking, and associated hardware, software, services, and techniques (Borghoff and Schlicter, 2000). In some circles, CSCW is used synonymously with the term “groupware”; however, the latter is attributed more frequently to the underlying technologies or tools (e.g., instant messaging, chat, whiteboards) and other practical solutions that support the collaborative work of groups and teams.

With regard to CSCW, the term "work" refers to the work system and associated components depicted in the Leavitt Rhombus in Figure 2, as well as the interactions between these components. Therefore, from a CSCW perspective, consideration of each of the four work system components (technology, people, process, and organization), and their interactions, is critical to the design of any collaborative system.

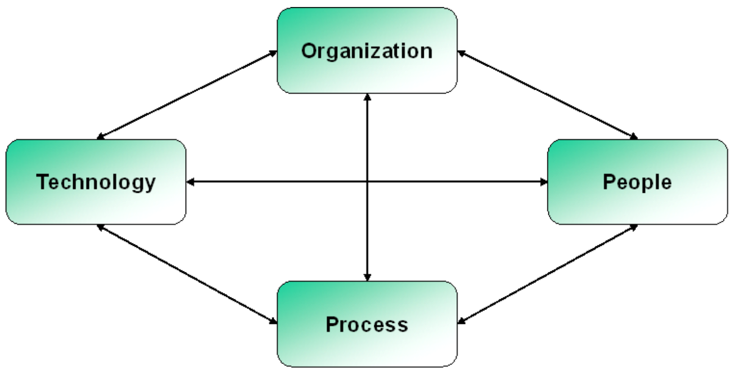

Figure 2. Work System Components – Leavitt Rhombus

1.2.3 Team

A team can be defined as a distinguishable set of two or more people that: 1) interact dynamically, interdependently, and adaptively toward a common goal and valued goal/objective/mission; 2) have specific roles or functions to perform; and 3) have a limited life span of membership (Salas, Dickinson, Converse, and Tannenbaum, 1992). It should be noted that the characteristics of "interdependence" and "limited life span", are arguably two key differentiators between *teams* and *groups*.

2.0 Study Approach and Analysis

The research conducted as part of the TASL program proceeded along three distinct, yet complementary vectors, all focused on supporting an analysis of collaborative systems and technologies from a socio-technical perspective. These vectors included: 1) a review and assessment of "human centered" research areas related to collaborative systems; 2) the development of a framework to support the assessment and evaluation of collaboration and teamwork in organizations (including data collection in a relevant environment to inform initial design and subsequent refinements to the framework); and 3) investigating the use of organizational simulation to support the design and assessment of organizational structures in command and control environments.

2.1 Literature Search and Analysis of Potential Research Areas

The TASL team was comprised of personnel (contractor and government) representing several academic disciplines including cognitive psychology, industrial and organizational psychology, computer science, human factors engineering, and logistics. The composition of the team allowed us to take a multi-discipline approach to the task of assessing and formulating potential research areas related to the design, development, and evaluation of collaborative systems in logistics command and control environments from a socio-technical perspective. In performing the literature search and analysis of potential research areas, our goals were to acquire a better understanding of current methods, tools, and measures that might be leveraged to support a socio-technical analysis of collaborative systems and technologies, and to identify potential gaps where additional research was needed. In approaching this task, a series of workshops were planned and conducted that brought together members of the TASL team representing the areas of expertise identified above (Appendix A).

During the first workshop, the focus was on developing some common ground and understanding with respect to the objectives and goals of the TASL research program, bounding the "problem space" to support the discussions leading to the formulation of potential research. The model shown in Figure 3 was derived to more clearly delineate the scope and objectives of the TASL research program and to help formulate specific focus areas related to the design, development, and deployment of collaborative systems to be explored further in the workshops that followed.

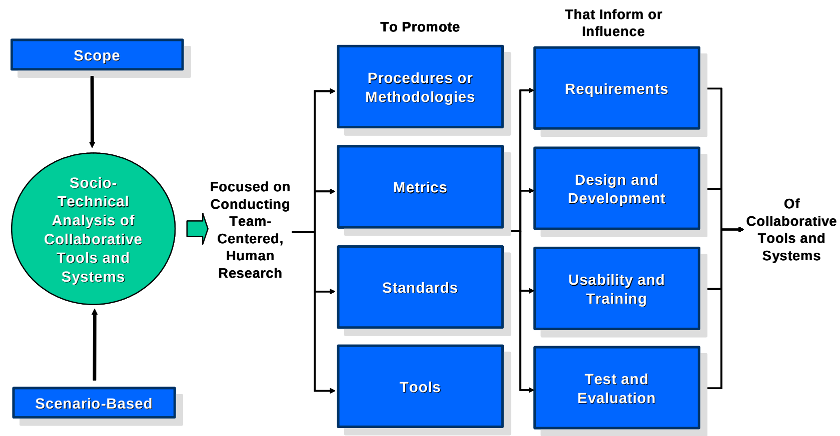

Figure 3. Model for Assessment of Potential TASL Research Areas

During the second workshop, the TASL team focused attention on discussing and developing potential areas of interest and related questions corresponding to one or more of the model components depicted in Figure 3 (e.g., "metrics" is directly related to the system development phase encompassing "test and evaluation"). The analysis and discussions of each of these components, as well as consideration of the skills and capabilities of TASL team members, resulted in the formulation of four specific, "human-centered" areas of potential research that included the following:

- Organization / Process / Culture
  - Barriers to Cross-Agency (Cross-Functional) Collaboration
  - Dimensions of Organizational and Technology Influences on Collaboration
- Training
  - Impact of Collaborative Systems on Training
- Evaluation and Assessment
  - Assessment of Collaboration in Logistics Planning - Methods and Measures
- Design and Visualization
  - Construction of a Common Operating Picture in Dynamically Changing Environments

The specific research questions discussed and developed for each area above are included in Appendix B. A team lead and supporting members (based on skills and interest) were assigned to each of the areas identified above and tasked with conducting a more thorough literature review and investigation of their respective areas. This included completing a more thorough domain analysis and associated literature search activities for their respective areas, and developing a plan that outlined proposed research efforts that might be pursued under the TASL program. In developing these research plans, teams were advised to focus attention on collaborative planning and/or command and control systems in an Air Force or joint logistics environment.

A final workshop was convened to bring together team members representing the four topic areas so they could present the results of their literature search and domain analysis activities, as well outline and discuss proposed topics for further research and investigation intended to address the questions posed for their respective areas (see Appendix B). A summary of the results of the literature search and analysis for each of these areas identified above is included below, and presented in more detail in separate reports that were developed and delivered to AFRL/RHAL (see Appendix B for report references).

2.1.1 Organization / Process / Culture

In addressing this area, we were concerned with gaining a better understanding of previous and on-going research related to cross-agency collaboration (particularly virtual collaboration in Air Force or other military domains) with an emphasis on a) identifying barriers or impediments to collaboration, and b) the influences of technology and organization on collaboration. With respect to the former, we discovered that there was little, if any research directly addressing cross-agency collaboration in Air Force command and control and logistics environments. In fact, the topic of cross-agency or interagency collaboration was most frequently discussed in the area of public health via analysis of case studies. The literature search did reveal a significant number of journal articles, and technical papers related to collaborative technologies and the impact on teamwork, including Wainfan and Davis (2004), who investigated the topic of virtual collaboration and identified potential barriers or problems in collaboration based on the medium involved (face-to-face, video conferencing, audio conferencing, or computer mediation communication). Based on the work of Wainfan and Davis, as well as our review of other sources, we identified some key benefits and barriers to collaboration that might be of interest to the TASL program (see Figure 4).

Benefits of Virtual Collaboration

- Greater equality of participation
- Broadening reach
- Rapid response time
- Adaptability
- Time and money
- Meets "real-world" demands
- Better than FTF for generative tasks

Barriers to Virtual Collaboration

- Information loss
- Depersonalization
- Reduced cohesion
- Reduced participation
- Leadership emergence suppressed
- Adversarial local coalitions
- More extreme decisions – Risky Shift
- Disinhibition – "Flaming"
- Delayed, more fragile trust
- Increased cognitive load

Figure 4. Benefits and Barriers to Virtual Collaboration

It is important to note that some of the benefits and barriers identified in Figure 4 may be situation specific. For example, greater equality of participation is touted as a benefit of virtual collaboration in that computer-mediated collaboration allows one to contribute to the conversation without interrupting others. Further, authority is less visible in computer-mediated collaboration, often reducing inhibitions. As a result, more ideas are generated and more team members find a voice in the conversation. However, there may be circumstances in which this open dialog is unwelcome and even a hindrance to decision making or planning. Therefore, it was determined that it would be important to consider the context in which the original research was conducted, and to perhaps prioritize those elements that seem most likely to be substantial benefits or barriers in the context of TASL program.

In investigating the influences of technology and organization on collaboration, a fairly broad literature review did not address the issues (and associated impact) that

Shalin, Bass, and Wales (2005) have observed in real government settings. Technology needs analysis did not appear to be principled—haphazard at best, and politically driven at worst. In this case, possibly developing a more objective foundation (and corresponding culture) for identifying useful technology could promote a more efficient and effective use of resources.

The impact of centralized and decentralized software development practices on the efficiency of technology development versus resulting work practice needs to be addressed. Efficient technology development can result in an inefficient work practice rife with workarounds, which are often hidden to the outside observer. In some cases, the management that makes decisions is not sufficiently engaged in the current demands of the task environment, and primarily rewarded for software delivery that is within budget rather than helpful for the real challenges. Tinkering with interfaces and broadcasting systems – the sorts of interventions one finds in the literature – are likely irrelevant in the face of these much more pervasive influences. In addition, they cannot be understood by examining behavior in the two-hour laboratory experiment. It was concluded that long term, integrative research would be required to provide a much more principled foundation, with quantifiable consequences, for the design of technology to support collaborative work.

2.1.2 Training

The focus of our literature search and investigation pertaining to the area of training was on the impact of collaborative systems on training from a socio-technical perspective – primarily the impact on the design, development, delivery, and evaluation of training supporting teams using collaborative systems. Our review of the literature revealed extensive but largely non-overlapping lines of research. We found substantial research on teams—their function and processes as well as outcomes of teams (both affective and performance), but much of the research focused on team processes, e.g., how members communicate, what they communicate, and how members manage conflict. Similarly, we found a large body of research on how to train people. However, this literature was largely focused on the individual level, although a smaller and more recent line of research has focused on training teams. In this research, much of the focus has been on ways to increase shared understanding of "taskwork" and teamwork; a heavy focus has been on cross-training.

There have been notable attempts in research on individual level training to identify contextual/situational and individual factors that affect training outcomes. The best known models addressing these issues are provided by Quinones (1995, 1997), Baldwin and Magjuka (1997), and Mathieu and Martineau (1997). There is substantial overlap between the models in the identified contextual/situational and individual factors. Key contextual/situational factors include factors in the organization (e.g., climate, rewards, goals, situational constraints, participation, management/organizational support) and in groups (e.g., group composition, cooperative group norms). Key individual factors include demographics (e.g., age, gender, race), motivation (e.g., self-efficacy, expectancies), knowledge, skills, and abilities developed through education and work experience, personality factors (e.g., conscientiousness, openness to experience, extraversion, goal orientation), needs (e.g., affiliation, achievement, dominance) and work attitudes (e.g., job involvement, career attitudes). However, clearly other contextual/situational or individual factors could also play a role in training outcomes, including aspects of the external environment (e.g., government regulations, competition, uncertainty), organizational structure (e.g., formalization), or groups (e.g., roles, including conflict or ambiguity, status, size).

More recently, researchers have attempted to identify contextual/situational factors affecting team training outcomes. Kozlowski and Salas (1997) provided one of the most comprehensive models addressing these issues, identifying techno-structural and process factors at the organizational, team, and individual levels. Techno-structural factors translate roughly into contextual/situational factors, particularly those factors that relate to task components or technology. Process factors translate roughly into individual, interpersonal/social, and organizational factors relating to interaction. Moreover, Kozlowski and Salas pointed out that interactions were likely to occur 1) between techno-structural and process factors within one level, and 2) between factors on different levels. They discussed these interactions using the term congruence, e.g., congruence between team and individual level goals.

Kozlowski and Salas (1997) further noted that individual difference factors (possess by team members) are likely to play a role in the effects of techno-structural or process factors at the individual, team, and organizational levels. In brief, at the individual level, Kozlowski and Salas identified technical skills and knowledge (techno-structural factors) and human process skills and knowledge (process factors). At the team level, they identified task interdependence, technology, and structure (techno-structural factors) as well as teamwork, leadership, team climate and team coordination (process factors).

Finally, at the organizational level, Kozlowski and Salas (1997) identified goals, strategy, resources, technology and structure (techno-structural factors) as well as vision, rewards, leadership, organizational culture/climate (process factors). Thus, the Kozlowski and Salas model seemed to provide a good starting point for identifying socio-technical factors that could be addressed as part of the TASL program. Also, their work in conjunction with the previously mentioned training models (e.g., Quinones, 1995, 1997) highlights the large number of factors that could play a role in training for collaborative computer-supported work.

So from a literature review and analysis of the impact of collaborative systems on training, two overlapping streams of research seem to emerge. The first stream of research focuses primarily on training at the individual level and is focused on the training and transfer of required KSAs (knowledge, skills, and abilities), and relies on both lab and field evaluation approaches. The other stream of research would focus on teams—their processes (e.g., communication, coordination) and effectiveness (e.g., affective outcome, performance). This line of research relies on the case study, lab, and field approaches. As the level of analysis rises, i.e., from individual to team to organization level, we would expect to see corresponding shifts from a lab experiment, to field study, to case study approach.

2.1.3 Evaluation and Assessment

The area of evaluation and assessment of collaborative systems investigated relevant research in military and nonmilitary research (emergency operations, business, sociology, software design and medicine) associated with methods, metrics and tools that could potentially support an evaluation and assessment of collaborative systems in military logistics operations relevant to the TASL program. We discovered that current evaluative methods generally fall into one of three categories to include 1) descriptive methods, 2) assessment methods, and 3) diagnostic methods. These methods are portrayed in Figure 5.

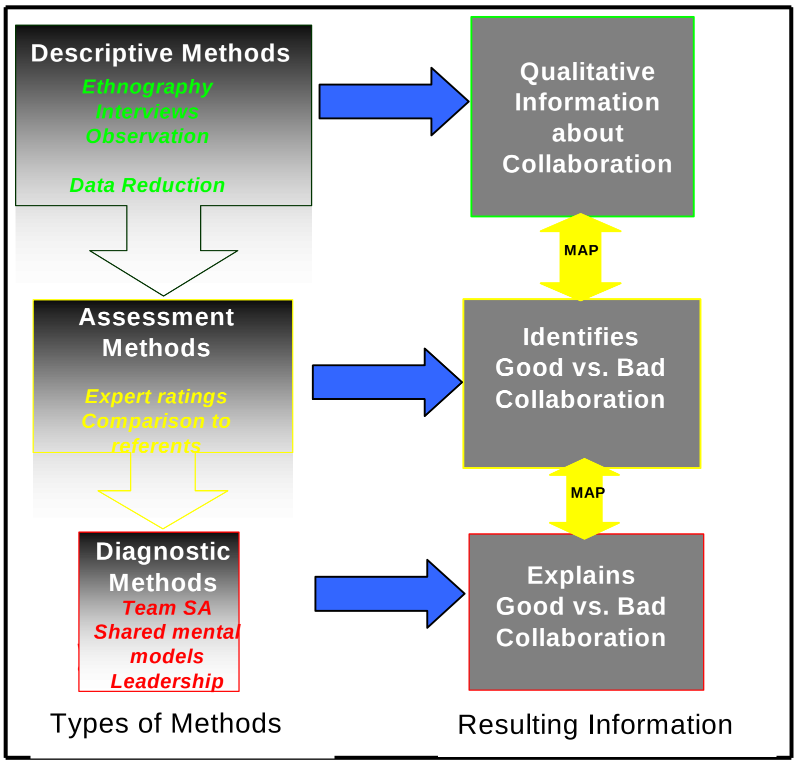

Figure 5. Types of Evaluation Methods

Descriptive methods represent a first step in evaluating collaboration and serve to "paint a picture" of the collaborative process. These methods define tasks or describe domains. Examples of methods in this category are cognitive task analysis, ethnography, and interviews that result in qualitative descriptive results. Along with these methods, come data reduction techniques and representational formalisms that take the often unwieldy data and reduce them to a form that is meaningful and succinct by highlighting trends, patterns, or frequent events. Examples of this kind of data reduction include concept maps, multidimensional scaling, and social networks. The end product of these methods is a description of the collaboration, but not an evaluation of it. *Assessment methods* take the descriptive information to the next step or collect new information that is more evaluative in nature. This step usually involves comparing a description or reduced description of collaboration to an expert or ideal state. For example, how does the collaboration “stack up” to one known to be highly effective? Expert ratings of collaboration fall into this category as do evaluations of social networks by quantitative comparison to some standard or by quantifying choke points in the diagram, for instance. The last class of methods, *diagnostic methods*, take assessment methods one step further in that they move from a pure assessment of the collaboration (e.g., good vs. poor, 90% vs. 50%) to a richer explanation of the collaborative behavior underlying the assessment. So for example, measures that go deeper than effectiveness to focus on collaborative behaviors such as situation assessment, sense making, conflict management, leadership, shared mental models, etc. and that tie these behaviors to the assessment fall into this category. Note that just describing the behaviors is not diagnostic until a connection is made to the assessment.

In this literature review, most of the methods uncovered could be classified as descriptive, though a few involved assessment. There are virtually no measures that fall into the diagnostic category, though there is some research that is beginning to investigate this topic. This imbalance is a reflection of the state-of-the art when it comes to understanding and evaluating collaboration. Diagnostic measures require a very good understanding of what good collaboration looks like within a domain of interest and how this is achieved. Based on our investigation and analysis, both of these knowledge bases seem to be lacking.

Another descriptive method worth mentioning involves ethnography (involving primarily observation) which provides largely descriptive data on collaboration. One issue associated with this method is the validity of the interpretation of ethnographic data, even at the level of initial observation. Gerstl-Pepin and Gunzenhauser (2002) examined the paradoxical process of interpretation in collaborative team ethnography. They utilized examples from work in a collaborative team evaluation of the North Carolina A+ Schools Program. They found conflicting assumptions, research paradigms, races, genders, class backgrounds, and research interests. They examined three paradoxes: interpretive differences on the research team, representation of diverse voices in the research process, and conflicting roles as evaluators and critical researchers. Collaboration led to a greater understanding through multiple meanings, which led to greater fragmentation and uncertainty. Benyon, Turner, and Turner (2005) discussed the use of ethnographic techniques to support the evaluation of cooperative working environments. Their study suggested that ethnographers should act as evaluators of early concepts or prototype designs before requirements are finalized, and while the design is too immature to benefit from user feedback.

Based on our analysis of evaluation and assessment of collaborative systems, we concluded that in order to fully evaluate collaboration within a specific domain, methods need to be adapted or developed for all levels of analysis. There are a number of descriptive methods available that when coupled with data reduction techniques, can provide good summaries of the collaborative process. What is primarily needed is a mapping of these types of descriptions onto a measure of collaboration effectiveness (e.g., expert ratings, comparison to referent) and then a mapping to collaboration behaviors associated with effective or ineffective outcomes. Just as assessment measures require performance criteria for comparison, diagnostic measures require behavioral criteria for comparison. So in order to develop evaluation methods that assess and diagnose collaboration, work is needed to develop and validate measures of collaboration effectiveness and collaboration behavior such as situation assessment, leadership, and shared mental models. Descriptive methods that might be applied to logistics collaboration include observations, ethnography, and expert interviews. The resulting data can be further analyzed through data reduction techniques to generate communication or social networks. As metrics for collaboration effectiveness and collaboration behaviors evolve, these descriptions can be associated with a much richer array of evaluative information.

2.1.4 Design and Visualization

Our review and analysis in the area of design and visualization was multidisciplinary in nature and focused on military command and control (C2) systems while aiming at a collection of literature that has specific applicability to the socio-technical aspects of Air Force (AF) logistics and humanitarian logistics. We focused particular attention on military C2 and logistic domains that involve multiple levels of teamwork, and that are often distributed and asynchronous in practice. The objective of this review was to gain a comprehensive understanding and to pinpoint multiple perspectives of what has been referred to as the *common operational picture* (COP). The term COP is typically used to describe a visual representation of aggregate battle space tactical, operational, and strategic information. COP is an information tool used in command control centers to generate situational awareness (Hager, 1997).

Modern joint military activities employ the necessities of network-centric warfare, complex information fusion, and emerging interconnected events that are subject to multiple time scales, high stakes actions taken under uncertainty and stress, and advanced sensors that deliver a glut of information in heterogeneous representations and formats. Core activities involve multiple teams working together to pursue a given purpose, mission, or task. Unfortunately, owing to the tremendous demands and pressures of operations, human teamwork and operational readiness are often overcome by events that lead to information overload, gaps in knowledge sharing/congruity, inadequate information seeking and sharing, task saturation, breakdowns in attention, miscommunications, impending failures, and miscalculations experienced during both routine and non-routine activities.

Contemporary patterns of military decision-making require reassessment of traditional perspectives to enable cognitive readiness and agile operations that correspond to dynamic threat situations of the 21st century. As an example of the way interdisciplinary collaboration has evolved, multiple teams/organizations encounter situations of uncertainty within highly vulnerable – even volatile – environments, but are now armed with the capability of fusing information through technologies that promote “anytime, anywhere” mobile teamwork. These encounters are often unexpected, require joint construction of knowledge among distributed forces, and necessitate perception of an amorphous and equally distributed threat force. Previously, individual analysts and tactical units (i.e., teams) have not had the broad bandwidth, information retrieval-search capabilities wherein both national-level and local-level intelligence can be brought to bear upon a source problem in real time. This high information profile for a situation – at first pause – may seem to provide a decisive tactical advantage. However, upon closer reflection, what often occurs is that individual analysts may be overwhelmed with excess information that causes a person to engage in multiple cognitive processes to search and cycle through what is relevant based on what they are experiencing. For practical work this means that individual workers are often tied to their teamwork by the levels of information they encounter, and concurrently, by how these levels of information are interrelated to the group process or product. Because these transactive, emergent elements of teamwork are often mediated by information and communication technologies, it is critical that intelligent interfaces bring teams together to 1) produce high situational awareness, 2) reduce information overload, and 3) effectively allocate functions/roles to enhance cooperative work. These formative conditions of work have been the foundation of which the statement of need for a COP has evolved.

There is much to be explored and learned from COP failures and successes given the differing forms of implementation in real environments. However, it is clear that most COP artifacts are not very user-centric, not typically designed through participation with active teams, rarely consider the ecological or contextual perturbations that require adaptive activities, generally ignore lessons learned from ethnographic data, and are not particularly informed from current CSCW research. When considering all these shortcomings, it becomes clear that COP is predominantly a techno-centric enterprise that results in some form of artifact. Although more experimental studies have begun, the area is woefully underdeveloped from a research perspective. In summary, there is much opportunity for future research evolving from the TASL program to explore both the concept and artifact viewpoints using fieldwork as well as experimental lab research.

2.2 Framework for Evaluation of Collaboration and Teamwork

Traditional approaches to the design and development of information systems have concentrated on the delivery of technology rather than emphasizing the human and organizational characteristics (Iqbal, Gatward, and James 2005). The design and development of collaborative systems and tools have also been approached in the same manner, with little if any regard given to cognitive, social, cultural, and organizational impacts. Many collaborative tools and systems exist, but many fail (with respect to being actually fielded or fully utilized) due to inadequate evaluation of user requirements, product development, and implementation. While there appears to be fairly widespread recognition of the impact of the socio-technical influences associated with collaborative systems, there is little if any research related to understanding how to better address these influences (individually and collectively) to better inform the design, development, and evaluation of collaborative systems. One of the more significant problems is that metrics and models to evaluate collaborative tools are lacking, therefore indicating that what is needed (at least in part) is a framework for examining socio-technical issues as they pertain to collaboration. Developing a framework for evaluation of collaboration technologies is an ambitious undertaking. However, as technologies and tools supporting collaboration continue to evolve, and the nature and types of work activities and environments (or settings) they support become increasingly more complex to understand, the need for an evaluation framework has become ever more crucial. Therefore, it was decided that making some progress towards the development and refinement of a framework for assessing collaboration was another logical vector of research to pursue under the TASL program. The focus of this research was twofold - first to investigate what, if any, frameworks or models currently existed for assessing or evaluating collaboration or collaborative systems, and second, to develop and assess the utility of a prototype framework that could support the evaluation of socio-technical factors in collaborative environments.

In researching the literature related to current models or frameworks for evaluating collaboration, Polivka's (1995) conceptual model for interagency collaboration (see Figure 6) was perhaps the most promising framework found. In this model, Polivka identifies three categories of input to the collaboration environment: Environmental Factors, Situational Factors, and Task Characteristics. These categories are consistent with the conditions associated with many collaborative domains, including the military. For example, it is important that agencies are aware of the goals and capabilities of other agencies in the collaborative environment, the complexity of the task must be well understood, and the social priorities must be well articulated. These elements are routinely captured in case studies and lessons learned, and are often incorporated into training programs, formal exercises, and standard operating procedures. As collaborations begin to unfold, Polivka's model identifies several transactional factors that affect the means by which agencies interact with one another. These transactional factors tend to be somewhat dynamic and are adapted in response to environmental factors, situational factors, and task characteristics. For example, as the resource channels become strained, the intensity of the collaboration increases. In emergency response, comparisons between effective resource utilization for a tornado (McEntire, 2002) and resource utilization for a major hurricane (e.g., Katrina in 2005) are quite different. The magnitude of resources required for hurricane Katrina were massive in comparison with the tornado relief efforts in Ft. Worth, Texas, which was reflected in the intensity of the respective response efforts and the complexity of the collaborations.

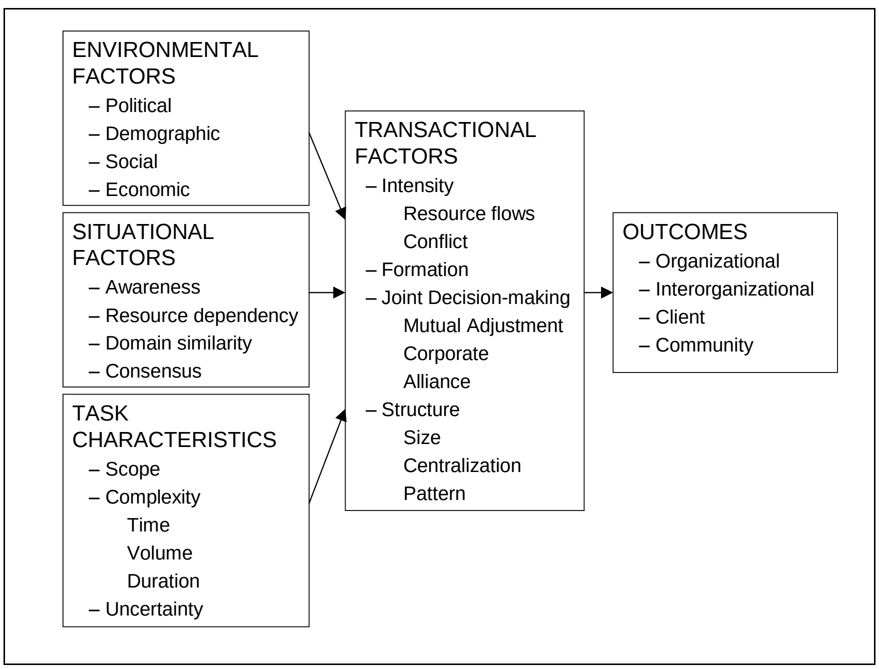

Figure 6. Polivka's Model for Interagency Collaboration

Another transactional factor identified by Polivka is that of formalization. The model establishes the importance of recognizing both the formal and informal agreements as well as pre-existing rules in interagency collaboration. Agencies prepared in this way have better success when challenges arise. For example, when formal procedures are not appropriate, teams that can readily adapt informal procedures are able to progress more rapidly. Symon, Long, and Ellis (1996) specifically address the importance of recognizing both formal and informal exchanges between agencies in health care settings. In their examples, they identify situations in which unexpected events caused formal procedures to break down and how various agencies successfully and unsuccessfully addressed these transitional exchanges with informal methods and procedures.

Polivka identifies three types of decision-making: Mutual Adjustment, Corporate, and Alliance. Mutual Adjustment decision-making is where there are only a few common goals between agencies and a few individuals adjust to accommodate those goals or specific situations. Power is decentralized in this method. Corporate decision-making is more hierarchical and authoritarian. With corporate decision making, formal rules are established and power is very centralized. Alliance decision-making is a hybrid of both Mutual Adjustment and Alliance decision-making with two sub-categories that include: 1) federations and 2) coalitions and councils. Federations consist primarily of administrators who carry out the actions as directed by unit level decision makers. With coalitions and councils there are no administrators; decision makers are the professionals making decisions at the unit level. An important distinction in these bodies of decision makers is that with Corporate decision-making decisions are from the top down. With Federation-type Alliances, the decisions are made from the bottom up (i.e., at the unit level up to the administrators).

Although Polivka's conceptual model was developed in a domain quite far removed from military logistics (i.e., public health), this foundational work seemed to serve as a useful starting point for considering cross-agency collaboration across a range of domains. This is true even though specific elements within the boxes of Figure 6 may change in importance across domains or even scenarios within a specific domain of interest to the TASL program. In discussing the use of Polivka's framework during the third and final workshop, it was concluded that while the framework might prove useful in attempts to describe or assess collaboration, as our understanding of collaboration and how to assess it deepened, this framework would provide little guidance in terms of diagnosing collaborative processes. Therefore, further research was undertaken under the TASL program to develop a framework suitable for assessing collaborative technologies from a human and organizational perspective, recognizing that simply testing collaborative technologies and systems (hardware/software) from a reliability and network connectivity standpoint does not guarantee successful implementation.

The prototype framework developed and evaluated in part under the TASL program is portrayed in Figure 7. It is a unified framework intended to allow researchers to examine factors that influence collaboration within socio-technical systems. Such an approach addresses the impact of collaborative technologies from a systems' perspective by examining factors at the individual, team, and organizational levels (Ritter, Lyons, and Swindler 2007). The present model integrates methods from psychology, sociology, and anthropology into a comprehensive framework to assess and evaluate barriers to collaboration in organizations from a human-centric perspective. Such an approach addresses the impact of collaborative technologies from a systems' perspective by examining factors at the individual, team, and organizational levels. The prototype model is not intended to consider all barriers to collaboration at this point. For purposes of the TASL program, we included barriers thought to be relevant to collaboration between logistics teams. These barriers include: information loss, reduced trust, reduced cohesion, formation of local coalitions, and suppressed leadership emergence (see Ritter et al., 2007 for a more detailed discussion of these barriers).

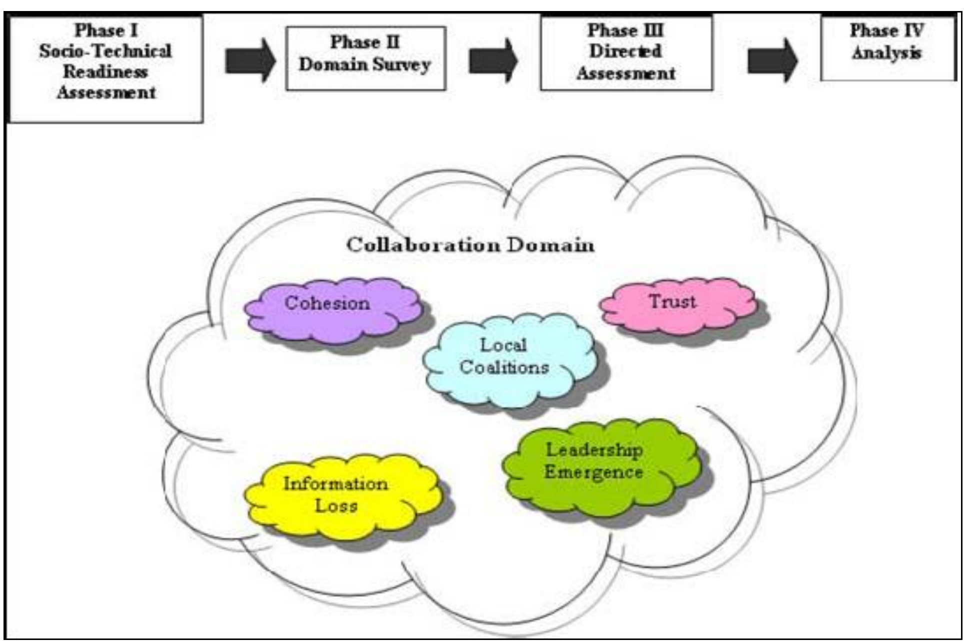

Figure 7. Prototype Framework for Assessing Collaboration

There are four phases outlined in the prototype framework depicted in Figure 7 including: Phase I - Socio-Technical Readiness Assessment; Phase II - Domain Survey; Phase III - Directed Assessment; and Phase IV - Analysis. The primary goal of Phase I is to create a high-level, profile or perspective of the "work system" that addresses the organization, people, processes, and technology. The basic product resulting from this phase includes a general description of the environment (organizational mission, products/services, high-level overview of business/work processes, business systems, etc.). The methods employed in gathering this information would include survey instruments, individual interviews, focus group discussions, and possibly nominal group techniques. In Phase II, *Domain Survey*, the emphasis is on obtaining a detailed understanding of the domain, including a more in-depth understanding of the nature of the work, information flows, communication and coordination of work activities, and potential barriers (and facilitators) to collaboration that exist within the organization. Methods for acquiring information and data in this phase include ethnography (i.e., a qualitative description of a group, organization, or culture), descriptive questionnaires, more detailed, structured interviews, and possibly social networking techniques to obtain insight on patterns of interaction between people/functions within the organization. The end product of this phase is a more detailed description of the organizational profile characterizing the nature of collaboration breakdowns and/or collaborative successes in the team or organizational context. In Phase III, *Directed Assessment,* the objective is to attempt to quantitatively measure the barriers and/or facilitators identified in the Phase II. There are three primary methods that can be applied in this phase including guided observations, questionnaire-based assessments, and performance data. The observations in this phase will be directed toward some phenomenon of particular interest and coded to provide quantitative data. For example, if reduced trust was identified as a barrier to successful team collaboration in Phase II, then behavioral indicators of trust, such as whether or not a team member rechecked another team members' work, could be used to measure the level of trust between team members. The analysis and results of this phase are intended to produce a set of quantitative data based on the collaboration metrics of interest for the particular domain under study.

The collaborative framework described is intended to be flexible enough to accommodate the unique needs of various domains in addition to logistics. By using this framework to evaluate the utility of current methods and tools to assess collaboration, and support research leading to the refinement of the same (or development of new methods/tools), we can selectively apply methods and tools to meet the unique demands encountered in various domains. Specifically, we see this framework as being useful to supporting the following:

- Assessing collaboration for existing systems/teams in organizations
- Comparing/contrasting the effects of various organizational factors on collaboration
- Evaluating the impact of various tools on team collaboration
- Informing and supporting the design of collaborative tools or systems by providing a framework for assessing the human (team) aspects of collaboration

The development of the prototype framework for assessing collaboration discussed above spawned the design and undertaking of two notable experiment and field evaluation efforts that were intended to provide an opportunity to begin to examine and evaluate our proposed framework in more detail.

The experimental effort was titled the "Computer-Based Aerial Port Simulation" (CAPS). The objectives for CAPS were: 1) to develop a computer-based laboratory task that would require collaboration within a distributed logistics network; and 2) to examine social and psychological factors that influence team performance and collaboration within computer-based distributed teams. CAPS is an interactive, computer-based simulation program that models specific tasks or activities accomplished by multiple logistic functions at an aerial port (Air Force, Air Mobility Command organization). The aerial port functions modeled include the Air Terminal Operations Flight (ATOF), Ramp Services, Passenger Services, Fleet Services, and Cargo Services. These functions, as well as the specific team and individual factors to be evaluated as part of the CAPS experiment, are shown in Figure 8. The design and development of the CAPS software also incorporated computer-mediated communication capabilities such as a "chat" to support experiment activities; specifically the coordination of tasks performed by experiment subjects (see Lyons, Seyba, and Ames 2006 for more details).

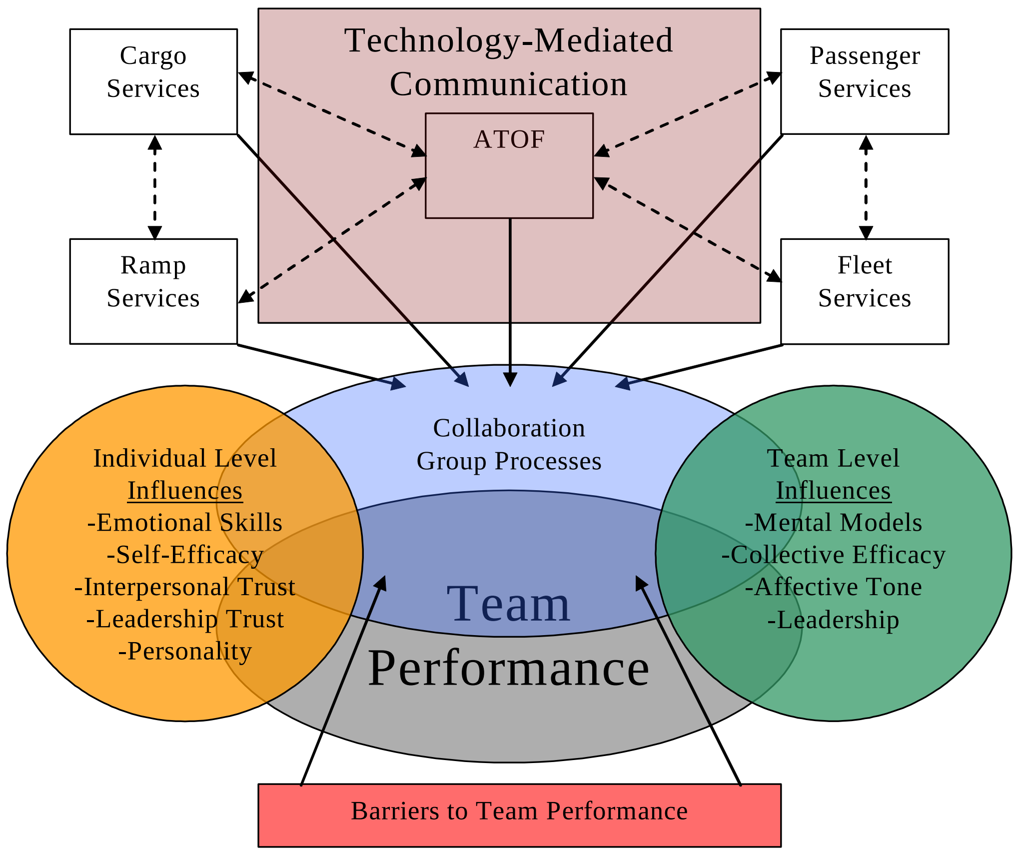

Figure 8. High-Level CAPS Experiment Architecture

The CAPS experiment was intended to support an examination of social and psychological factors affecting individual and team performance, and collaboration within a computer-based distributed team context. The CAPS experiment platform continues to support other AFRL/RHAL sponsored and in-house research efforts, including the "Experimental Evaluation of Collaborating Teams" research task being accomplished under a separate TACS delivery order.

In addition to the CAPS experiment effort, AFRL/RHAL was also successful in establishing a relationship with the Air Mobility Command, Tanker Airlift Control Center

(TACC) at Scott AFB, IL to obtain support for collecting data and information in support of the TASL research program. The intent here was to conduct a domain analysis in a representative logistics environment that would allow us to apply and assess methods associated with our framework for evaluating collaboration. This field study was also intended to directly support the TACC leadership in better understanding their work processes and information flows as part of planning activities for the US Transportation Command Fusion Center initiative.

The TACC represents a command and control environment responsible for planning and executing airlift and tanker missions as the Air Component for the United States Transportation Command (USTRANSCOM (Distribution Process Owner for the Department of Defense)). These missions primarily include: 1) the movement of forces, equipment, and supplies to/from locations worldwide, 2) aeromedical evacuation, and 3) air refueling. The research accomplished in part under the TASL program with respect to the TACC included a domain analysis that was focused on documenting the business processes, information flows, and organizational interactions (including external) of planning and execution functions within the TACC. The methods used to conduct this analysis included individual interviews, observations, focus group discussions, and survey questions. The survey questions were developed by AFRL/RHAL researchers in support of an overall organizational and cultural assessment that was undertaken as part of Air Force Smart Operations for the 21st Century program (AFSO21) efforts at AMC (separately contracted effort by AMC with Mainstream GS LLC). The questions developed by AFRL/RHAL and included as part of this assessment focused on assessing unit cohesion between members of functions within the TACC, as well as organizational and collaboration perceptions. The analysis, results and recommendations from the AFRL/RHAL research associated with this assessment are discussed in a separate technical report titled "*TACC Culture Assessment: Opportunities and Challenges",* dated 9 Jan 2007. In addition, findings and recommendations developed from the data collection, interviews, and analysis of TACC business process were documented in a separate memo to AMC and TACC staff functions, and formally presented to the TACC/CV by members of the AFRL/RHAL staff participating in the TASL research program.

2.3 Organizational Simulation

The third vector of research pursued under the TASL program was focused on investigating and exploring the feasibility and utility of using organizational simulation methodologies that could potentially support the development of a viable, in-house (AFRL/RHAL) capability to research organizational phenomena using computational methods, specifically simulations of organizational activity or structuring. This capability might help better inform the design of organizations utilizing collaborative systems. The domain of interest in this research was targeted toward Air Force Command and Control (C2) organizations, primarily organizations involved in the planning, monitoring, and execution of logistics activities (e.g., a Logistics Readiness Center), but also other Air Force and Joint C2 organizations (e.g., Air Mobility Command (AMC) Tanker Airlift Control Center (TACC), or USTRANSCOM Deployment Distribution Operations Center.

Organizational simulation involves the computational representations of people, their behaviors and interactions in response to the environment and each other (Rouse and Boff, 2005). Organizational simulations can provide a powerful framework for 1) testing and advancing theories related to organizational behavior, individual and team cognition, leadership, organizational constructs, etc. 2) supporting training and organizational learning, and 3) constructing situational based models to understand the potential impact of strategy, policy, and procedural changes, as well as the introduction of new systems, on overall organizational performance (and other factors). The Air Force, as well as other DoD Service components are undertaking numerous “transformational” initiatives (e.g., AFSO21, USTRANSCOM Fusion Center initiative, etc.) aimed at streamlining and improving our overall defense posture to effectively respond to current and future threats. These initiatives will undoubtedly impact (to some extent) current military doctrine, authority, policy, process, and organizational structures.

The focus of the preliminary research conducted under the TASL program was on investigating current organizational simulation models or systems to determine their suitability for researching the impact of various organizational designs or structures on individual, team, and organizational performance (in a command and control situational context). To this end, a literature search was conducted to investigate existing simulation software supporting organizational simulations, as well specific research related to the use of organizational simulation in various contexts. Numerous simulation packages were identified that were well suited for modeling business processes (particularly manufacturing, service oriented, and job shop processes), but very few that were specifically designed to model organizational constructs and variables or factors such as communication and information flows, skill levels, and reporting hierarchies. The research conducted by Ashworth and Carley (2007) served as a good baseline for gaining a better understanding of the capabilities and limitations of existing simulation models in addressing the impact of various organizational improvement initiatives involving strategy, policy, process, and/or system changes on organizational structures.

The two most promising models we identified through our literature search and investigation included SimVision®, a commercial off-the-shelf simulation package for modeling project oriented organizations, and POW-ER (Process, Organization, Work for Edge Research), a simulation platform supporting the computational modeling of organizations developed at Stanford University. Both the SimVision® and POW-ER software are outgrowths of the Virtual Design Team (VDT) research at Stanford University through the Collaboratory for Research on Global Projects (CRGP), headed up by Dr. Raymond Levitt. Dr. Levitt's Virtual Design Team (VDT) research group has developed new organization theory, methodology, and computer simulation tools to design organizations that can optimally execute complex, fast-track, projects and programs. The POW-ER software is primarily used to support continuing VDT research at Stanford (and other educational institutions) related to the modeling and validation of micro-level social, cultural, and cognitive factors in the context of models of project-oriented organizations.

Under the TASL program, AFRL/RHAL was able to secure a license for the SimVision® software from the National Aeronautical Space Administration (NASA) so we could do a preliminary evaluation to see if it might be suitable as a platform for supporting future in-house research in the area of organizational simulation beyond the TASL program. In addition, select members of the TASL team participated in a SimVision® training session to learn, in more detail, the process for constructing and validating SimVision® models. With respect to POW-ER, AFRL/RHAL has launched a new research task that is investigating the use of POW-ER as a platform to support further research in the area of organizational simulation, with the intent of possibly using POW-ER to model and validate the impact of general theories and empirical based models related to leadership, trust, etc. that could eventually be incorporated within organizational models to address the impact on organizational, team, and individual level performance. The primary (but not exclusive) contextual domain to inform research in this area would be logistics command and control type organizations such as the TACC or organizations within USTRANSCOM such as the Deployment Distribution Operations Center (DDOC) that are undergoing potential re-organizations due to transformation initiatives and manpower reductions.

3.0 Conclusions and Recommendations

As highlighted earlier, the TASL research program encompassed three primary research vectors to include: an analysis of "human centered" research areas associated with collaborative systems; the development of a prototype framework that could support the assessment and evaluation of collaboration and teamwork in organizations; and finally, an investigation of research and models supporting the simulation of organizations. Although the research associated with each of these vectors progressed independently (for the most part) over the course of the TASL program, they proceeded with the common objective of gaining a deeper understanding about collaborative systems and collaborative environments from a socio-technical perspective.

One significant finding from our research and "human-centered" analysis of collaborative systems was that although significant research has attempted to address socio-technical issues in computer science journals, the emphasis was primarily on the technological challenges and costs associated with software and hardware supporting computer-mediated communication, and much less about social, cultural, and organizational factors of interest to the TASL program. In contrast, the psychological literature focuses extensively on individual, social, and organizational factors in teams but less on how these factors should be addressed in the design, development, and evaluation of collaborative systems. Hence, what seems to be needed in moving forward is an integration of these broad lines of research, for instance, examining the effects of communication losses resulting from using collaborative systems and technologies for computer mediated communication to support virtual/dispersed teams. Two other topics for further research that should be included in this integrated approach include training and teams. The training research should focus initially on gaining a better understanding of the knowledge, skills, and abilities required to effectively use collaborative systems – beginning at the individual level, and progressing to look at the training of teams and organizations. The research related to teams should focus specifically on gaining a better understanding of team processes in representative C2 domains or environments. The purpose of this research would be twofold - to inform the training of teams working with collaborative systems, as well as to support the development of metrics to help better assess the effectiveness of communication and coordination between team members. The design and development of meaningful metrics to evaluate the human and organizational impacts of collaborative technologies and systems in C2 domains will be challenging and require a combination of both traditional experimental methods and ethnographic techniques.

The development of the prototype framework for assessing and evaluating collaboration presented in this report was an ambitious but worthwhile undertaking. As technologies and tools supporting collaboration continue to evolve, and the nature and types of work activities and environments (or settings) they support become increasingly more complex to understand, the need for an evaluation framework will become even more crucial to helping ensure the successful design, development, and implementation of collaborative systems. The initial research associated with the prototype framework has advanced our understanding of these complex issues. However, we realize that a more multi-disciplinary perspective will need to be developed and brought to bear to address the challenges associated with designing, developing and implementing collaborative systems from a socio-technical perspective. The current focus on technological capabilities for these systems is simply not sufficient as our prototype framework suggests. The proposed framework will help provide a better understanding of collaboration within organizations, and thus better inform the design, development and implementation of collaborative systems supporting these organizations.

The final vector of research undertaken as part of the TASL program focused on examining the domain of organizational simulation. This is a fairly rich area for future investigation considering most of the current models we identified and evaluated in our research (particularly those in academic settings) were still very experimental in nature, and only addressed specific aspects of organizational design, and factors impacting organizational performance. The SimVision® and POW-ER models evolving from the VDT research at Stanford University over the past 20 years seem to show the most promise for supporting future research in the area of organizational simulation in military C2 environments. The interest should be investigating the use of organizational simulation techniques to inform the design of military organizations and business processes based on social, cognitive, and cultural factors. For instance, we need to develop a better understanding of how factors such as leadership, trust, etc. impact communication and coordination, as well as individual and team performance under various organizational design constructs (e.g., centralized versus decentralized lines of authority). Advancing our understanding in these areas could help better inform decisions made regarding organizational realignments not only in military logistics C2 environments (e.g., TACC, USTRANSCOM Fusion Center), but other domains as well.

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Appendix A: TASL Research Program Workshop Principal Investigators

Dr. Deb Steele-Johnson

Dr. Steele-Johnson is an Associate Professor of Psychology in the Department of Psychology at Wright State University. Dr. Steele-Johnson's research interests focus on how people acquire complex skills, and factors that affect that process; as well as on how feedback, goals, other self-regulatory processes, and personal characteristics (e.g., need for achievement, goal orientations) affect learning and performance on complex tasks. This research has implications for motivation and training. As a member of the TASL team, Dr. Steele-Johnson will provide expertise related to gaining a better understanding of how collaborative systems change the way we train people.

Dr. Val Shalin

Dr. Shalin is an Associate Professor of Psychology in the Department of Psychology at Wright State University. Dr. Shalin's research interests include human workplace expertise and associated empirical and analytic methods to support the design and testing of workplace aiding and training technology. She also studies cognition in workplace settings, incorporating both experimental methods from behavioral science and observational methods from social science. As a member of the TASL team, Dr. Shalin will provide expertise related to organizational and technology barrier to collaborative work as it pertains to distributed teams.

Dr. Mike McNeese

Dr. McNeese is a Professor of Information Sciences and Technology, and the Director of the User Science and Engineering (USE) Lab at The Pennsylvania State University. Dr. McNeese's research interests include human interaction with information technology in complex environments, particularly collaborative systems that bring together the confluences of cognition, computation, collaboration, and context for given fields of practice. As a member of the TASL team, Dr. McNeese will provide expertise related to the design of advanced human-computer interfaces to support team-based, logistics planning and command control activities in distributed environments.

Dr. Alan MacEachern

Dr. MacEachern is a Professor of Geography and Director of the GeoVISTA Center at The Pennsylvania State University. Dr. MacEachern's primary research interests include the interaction between formalized visual and digital representations inherent in maps and geographic information systems; and human mental representation of space and space-time. As a member of the TASL team, Dr. MacEachern will provide expertise related to the visualization and representation of geospatial data and information supporting logistics planning and command control activities in distributed environments.

Dr. Nancy Cooke

Dr. Cooke is a Professor of Applied Psychology at Arizona State University's Polytechnic Campus, and the director of the Cognitive Engineering Institute (CERI). Dr. Cooke's research areas of interest include: cognitive engineering and knowledge elicitation with an emphasis on cognitive task analysis, team cognition, team situation awareness, mental models, expertise, human-computer interaction, command-and-control in unmanned aerial vehicles and emergency response systems. Dr. Nancy Cooke is a renowned expert in distributed team cognition and the evaluation of collaborative systems. As a member of the TASL team, Dr. Cooke will provide expertise related to the development of methods and metrics for evaluating team collaboration.

Dr. Waleed Smari

Dr. Smari is an Associate Professor of Electrical and Computer Engineering at the University of Dayton. Dr. Smari's primary research areas of interest includes the design and engineering of software and hardware for collaborative systems; parallel and distributed processing and networking, and performance evaluation of computing systems. As a member of the TASL team, Dr. Smari will provide expertise in the architecture and design of computer hardware and software applications related to computer supported cooperative work (CSCW).

Appendix B: TASL Proposed Research Areas and Questions

AREA 1 - ORGANIZATION / PROCESS / CULTURE

a. What are the technology and or organizational roadblocks to distributed collaboration?

b. How can we analyze proposed process changes for collaborative systems (task coupling, interdependencies)?

c. How can we remove barriers to cross-agency collaboration (including understanding the process of collaboration within logistics, and identifying and defining barriers to cross-agency collaboration)?

d. What is the impact of ad-hoc teams on collaboration?

References:

V. Shalin and D.Steele-Johnson, "Dimensions of Organization and Technology Influences on Collaboration", Report of Literature Review, December 2005.

L. Militello et al., "TASL Literature Review Summary: Cross Agency Collaboration", December 2005.

AREA 2 - TRAINING

a. How does distributed, computer-supported work affect the nature/type of training?

b. What is the role played by social, organizational, and technical factors in effective training in collaborative systems?

Reference:

D. Steele-Johnson and V. Shalin, "Training: How Collaborative Systems Change the Way We Train People", Report of Literature Review, December 2005.

AREA 3 - EVALUATION / ASSESSMENT

a. How can we assess collaboration in logistics planning (individual, group, organizational performance)?

b. How do we evaluate the effectiveness of collaborative technologies (human performance and evaluation tools for assessing collaborative technologies)? We may want to collaborate on this research with AFRL/IFSD.

Reference:

N. Cooke et al., "TASL Area #3: Evaluation/Assessment Literature Review", December 2005.

AREA 4 - DESIGN / VISUALIZATION

a. How do workers construct a common operational picture in an emerging or dynamically changing environment (team situation awareness)?

b. What do we need to understand about the spatial and temporal aspects of emerging or dynamically changing environments for members of team to work effectively? How can this effectively be distributed?

c. What is the requisite knowledge required for a knowledge manager?

- How do you coordinate in collaborative environment?
- See reference: "Knowledge Management in the Intelligence Enterprise" Good book applicable to the question posed.
- How does one know when to act?
- What is the metacognition?

d. What is the role of visual displays in facilitating collaboration?

Reference:

M. McNeese, "Understanding the Common Operational Picture from Near and Far", Report of Literature Review, December 2005.

Acronyms

AMC	Air Mobility Command
CAPS	Computer-Based Aerial Port Simulation
COP	Common Operating Picture
CSCW	Computer Supported Cooperative Work
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
JFCOM	Joint Forces Command
STREAM	Socio-Technical Readiness Evaluation and Assessment Model
STS	Socio-Technical System
TACC	Tanker Airlift Control Center
TACS	Technology for Agile Combat Support
TASL	Team-Based Assessment of Socio-Technical Logistics